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WITNESS my hand this
Eighth day of September 2003

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AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Applicant:

GOULBURN WOOL SCOUR PTY LIMITED

Invention Title:

EVAPORATION APPARATUS

The invention is described in the following statement:

AN EVAPORATION APPARATUS

Field of the Invention

The present invention relates to an evaporation apparatus. The apparatus can be applied to the drying of a waste liquid mixture which contains organic solid matter and will primarily be described with reference to this context. The invention has broad use in evaporative applications for all manner of other solid-liquid mixtures or for liquids which contain dissolved solids.

Background Art

Evaporative drying apparatus is known in the art, and can include basic drying basins or pans which are open to the atmosphere. In such equipment, reliance is placed on the sun or wind to dry a liquid-containing mixture placed in the drying basin or pan. On cloudy or cold days the drying process can be slowed or halted. In some situations it is undesireable to have an open evaporative drying system, for example because of seasonal rainfall which can actually increase the volume of water to be dried, or because of the possibility that birds or other creatures may attempt to land in or drink the water (which may contain toxic substances). In such instances, an enclosed evaporative drying apparatus is considered superior.

Enclosed apparatus for evaporative drying generally includes a fixed structure of some kind, such as a chamber or wind tunnel through which an evaporative gas such as air is caused to flow and be subsequently expelled, or a ventilated greenhouse which is heated or retains heat to cause liquid evaporation followed by expulsion of the moisture-containing gases. The known evaporation chambers are either made of rigid materials or are maintained in

shape by an interior structure such as a frame having ribs, purlins or the like. Such chambers can be complex to construct and are expensive to purchase. Once such evaporative drying apparatus is assembled, it is not a simple matter to move it to another location.

Generally both types of evaporative drying apparatus include a solid-liquid feed mixture containment in which the material to be evaporatively dried is placed. Access to this containment to allow periodic emptying of dried solids needs to be arranged, which adds further complicating features to either type of drying apparatus.

Summary of the Invention

The present invention provides an evaporation apparatus including:

- an evaporation chamber that is inflatable; and
- fluid flow control means for controlling the respective introduction and release of gas to and from the chamber to control the inflation of the chamber,

wherein in use the inflated chamber is adapted for containing a volume of liquid to be evaporated and carried out of the chamber by the gas in a vapour.

The invention can provide an improved enclosed evaporation chamber because the chamber does not require a complex inner or exterior support structure, so that the apparatus can be readily collapsed and moved to a new location. The evaporation chamber itself acts to contain the liquid to be evaporated, which further simplifies the apparatus for both operational and periodic cleaning purposes.

Preferably the fluid flow control means is used to control the gas pressure and the flow rate of gas within the chamber.

Preferably the fluid flow control means includes a fan for introducing gas into the evaporation chamber, the fan sealably positionable at a hole made in the wall of the chamber. Most preferably the fan is a variable speed fan.

Preferably the fluid flow control means also includes an outlet pressure release valve via which gas is released from the chamber, the valve sealably positionable at a hole formed in the wall of the chamber.

Preferably the evaporation chamber is an enclosure made of a flexible wall material. Preferably the enclosure is made of a plastic material. Most preferably the enclosure is elongate and tubular in shape.

Preferably the liquid to be evaporated can be introduced into the enclosure in a batchwise or a continuous manner via a liquid introduction port located in the exterior of the enclosure.

Preferably the vapour released from the chamber can be condensed by a condenser means located external of the evaporation apparatus.

Preferably the evaporation apparatus is adapted to be floated on a body of liquid.

Brief Description of the Drawings

Notwithstanding any other forms which may fall within the scope of the present invention, preferred forms of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows a perspective view of one embodiment of an evaporation apparatus in accordance with the invention.

Figure 2 shows a further perspective view of the apparatus shown in Figure 1.

Figure 3 shows a further perspective view of the apparatus shown in Figure 1.

Figure 4 is a schematic diagram of a sectional elevation of the apparatus shown in Figure 1.

Figure 5 shows a perspective view of part of the apparatus shown in Figure 1 when the part is disassembled from the evaporation apparatus.

Figure 6 shows a perspective view of another embodiment of an evaporation apparatus in accordance with the invention.

Figure 7 shows a further perspective view of the apparatus shown in Figure 6.

Figure 8 shows a further perspective view of the apparatus shown in Figure 6.

Figure 9 shows a perspective view of another embodiment of an evaporation apparatus in accordance with the invention.

Modes for Carrying out the Invention

Referring to a preferred embodiment shown in Figures 1 to 5, an evaporation apparatus 10 in the form of an inflatable elongate tube 12 is shown that is fitted with fluid control means in the form of an inlet gas fan 14 and a gas outlet hole 16. The capacity of the inlet gas fan 14 and the size of the outlet hole 16 are matched so that the degree of inflation of the tube 12 can be maintained. The tube 12 is generally made of a thick-walled plastic material although other flexible materials suitable for

containing gases and liquids are acceptable. One particularly preferred form of plastic material is outlined in the following description.

In use the inflatable tube 12 is partially filled with a volume of liquid 18 to be evaporated, as shown in schematic detail in Figure 4. The liquid 18 may be accompanied by or include solid matter 19, for example in a slurry or pulp, or may even contain dissolved solids or salts. In operation of the apparatus 10, the liquid 18 becomes heated in the tube 12 by solar radiation and is then vaporised to form a vapour 22. A flow G of a gas such as air is initiated through the volumetric space 20 located above the liquid 18 and in the tube 12. The flow of gas G is along the length of the tube 12 from the inlet fan 14 to the outlet hole 16. The flow of gas G carries the heated liquid vapour 22 out of the apparatus 10 via the outlet hole 16. The solid matter 19 remains in the evaporation tube 12, and in time a significant quantity of this material becomes deposited in the tube 12, which can be reclaimed as will be further described. Typically the liquid 18 which is evaporated is water, although the apparatus 10 has application to non-aqueous liquid evaporation situations.

The inlet gas fan 14 and the size of the outlet hole 16 are used to control the gas pressure and the flow rate of gas flow G within the tube 12 and thus the degree of inflation of the evaporation tube 12. In the preferred embodiment, the gas pressure in the evaporation tube 12 in use is maintained between 0.3 and 0.8 inches water gauge and the flow rate of gas through the evaporation tube 12 is 1.8 m^3/second. The outlet hole 16 can simply be an incision or cut made in the evaporation tube 12 wall at a distal end from the inlet gas fan 14. In other

embodiments the outlet hole can have a pressure release valve sealably fitted to it via which gas can be released from the evaporation tube 12, as another way of controlling the inflation of the evaporation tube 12 and the gas flow G therethrough.

The inlet gas fan 14 which is used for introducing air into the evaporation tube 12 is sealed in position at a hole 24 made in the wall of the tube 12 so that the air which is forced into the tube 12 by the fan 14 does not leak out of the tube 12 at the rim of the hole 24. This sealing can be by way of any suitable adhesive or substantially airtight clamping arrangement. A more detailed view of the gas inlet fan 14 and the way it is mounted in use to the evaporation tube 12 of the preferred embodiment is shown in Figure 5. The fan 14 shown in Figure 5 is a variable speed fan (of around 0.3kW power draw, and a maximum speed of 2850rpm) which is seated atop a fan tube 26 that increases in diameter in a conical manner just below the fan blade 28. The fan tube 26 diameter change has been observed to reduce the operational noise of the selected fan 14. The fan motor is located inside the fan tube 26. The fan blades and the top of the fan tube are shielded by an inverted conical rain guard 27 to prevent the ingress of rainwater into the fan tube 26. The fan tube 26 is positioned atop a support stand 30 which is seated on a rubber car tire 32. When located in position inside the evaporation tube 12, the tire 32 seats the support stand 30 onto a lowermost portion of the interior wall of the evaporation tube 12 and substantially reduces any vibrational wear on the plastic inner surface of that tube 12. The external perimeter of the fan tube 26 is positioned in the hole 24 in the tube 12 and sealed or clamped to the rim of the

hole 24 as described. In the preferred embodiment the hole 24 and the outer diameter of the fan tube 26 are 300 millimetres is diameter.

In addition to this, the support stand 30 has a float valve 34 mounted on it which indicates the level of feed liquid 18 (or liquid/solid mixture) inside the evaporation tube 12 during operation. The float valve 34 can actuate a liquid inlet/make-up valve to control the flow of liquid and/or liquid and solids in the evaporation tube 12. The new fluid/solid mixture to be treated by evaporation is passed into the tube 12 via a fluid inlet pipe 36. This fluid inlet pipe 36 passes liquid and solids etc via the fan tube 26 itself and into the evaporation tube 12. In still further embodiments the fluid inlet pipe can be located in a hole in any convenient position in the wall of the evaporation tube 12, and not necessarily associated with the hole 24 made for the inlet gas fan 14. In operation the liquid to be evaporated can be introduced into the tube 12 in a batchwise or in a continuous manner via the fluid inlet pipe 36, depending upon the type of liquid or liquid-solid mixture being dried and as the situation requires. Thus in some situations all of the liquid present can be evaporated so that the remaining solids or dissolved salts are completely dried, or alternatively the apparatus 10 can be operated continuously so that a large quantity of liquid can be evaporated over time to allow cumulative deposition of solid matter.

The apparatus 10 of the preferred embodiment is generally located in a trench 38 or other excavated recess in the surrounding ground 40 to provide extra storm and wind protection and stability, for example to prevent the tube from rolling movement. In further embodiments the in

use weight of the liquid and solids undergoing heating and evaporation in the evaporation tube 12 is sufficient to prevent the apparatus 10 from moving without being positioned in a ground recess. The edges of the trench 38 in the preferred embodiment are lined with car tires 42 to provide additional support for the sides of the trench 38 and to reduce any abrasion or wear on the exterior of the tube 12. The base of the trench 38 has a porous woven polypropylene underlay 46 placed therein, upon which the evaporation tube 12 is seated. This underlay 46 gives mechanical protection for the tube 12 against puncturing while also reducing the chemical degradation of the plastic material used to form the tube 12 by ground leachates etc. Depending on the terrain and the application, the presence of an underlay layer is optional. In the event of leakage from the evaporation tube 12, in further embodiments the underlay can be made of an impervious material to prevent spilled liquids and solids from entering the water table for some time until the leak in the tube 12 can be plugged.

The evaporation tube 12 of the preferred embodiment shown in Figures 1 to 5 is typically around 50 metres in length and around 4.5 metres in width, although in other embodiments the length can be up to around 150 metres and the width of the tube can be anything from 2 metres to 10 metres depending on the topography of the location. The tube 12 itself is made of a plastic material which is available in tubular lengths, and once a prescribed length of tubing is cut, the opposing ends may simply be rolled or tied closed and physically sealed or clamped airtight. In the preferred embodiment, the open ends of the tubular feed material are scrolled around a metal bar 44 which is then seated on the surrounding ground 40 at the ends of

the trench 38. The depth of liquid and solids contained in the evaporation tube 12 does not exceed the height of this bar, so that leakage does not become an issue. In still further embodiments, depending on the type of plastics in use, the ends of the tube may be welded or formed together. The curved upper surface shape of the inflated tube 12 is such that it naturally sheds rainwater to avoid pooling.

The plastic tubular material used for the preferred embodiment of the evaporation tube 12 is a commercially available product which has three distinct properties. The outer surface of the tube includes a ultraviolet light stabilising coating (to maintain product life while exposed to the sun over long periods), and the inner surface has a resin coating which ensures that the tube is resistant to chemical degradation by acids, alkalis, chlorides, greases, oils etc which may be found in the liquid/solid mixtures to be evaporated. The centre of the tube wall is made of a high strength polypropylene to give the tube structural strength. Thus the tube 12 can be placed in a location which is exposed to the environment (eg solar radiation), it may contain liquids and solids considered too chemically aggressive for some plastics, and still generally have sufficient strength to resist impact from tree branches, hailstones or other debris while maintaining a rigid tubular shape when inflated in use. With this particular type of material, plastic welding or other hot-forming is to be avoided, as this can cause damage to the inner surface resin coating that resists chemical degradation.

Referring now to Figures 6 to 8, a further preferred embodiment of an evaporation apparatus 100 in the form of an inflatable elongate tube 120 is shown that is fitted

with fluid control means in the form of an inlet gas fan 140 and a gas outlet hole 160. Once again the capacity of the inlet gas fan 140 and the size of the outlet hole 160 are matched so that the degree of inflation of the tube 120 can be maintained. The evaporation tube 120 is generally made of the same materials as described earlier for the evaporation tube 12. In all respects the evaporation tube 120 operates similarly to the evaporation tube 12, and thus a repeat description of the use of the tube 120 is not given here. Where indicated in Figures 6 to 8, like parts are given corresponding numbers with an additional "0". In the embodiment of Figure 6 to 8, the outlet hole 160 has a tubular section 170 protruding therefrom.

In still further embodiments the evaporation tube can be made of a reinforced flexible wall material, such as plastic with reinforcing mesh fitted thereinto for extra strength. In still further embodiments the evaporation chamber need not be elongate and tubular in shape, but can be rounded or oval in shape, or any other convenient shape that plastic material can be extruded or formed into.

The invention can provide an improved enclosed evaporation chamber compared with the known apparatus because the chamber does not require a complex inner or exterior support structure, so that the apparatus can be readily collapsed and possibly moved to a new location. A metal rib structure in a solar-heated plastic greenhouse can become extremely hot, and these hot metal rafters or purlins can melt any plastic tubing or sheeting that comes into physical contact with the rib or support structure. In normal usage of the preferred embodiments, it may be expected that the temperature of the flow of gas G and liquid vapour 22 will reach around 80°C due to the retention

of solar energy in the tube, so a support structure which has a high heat capacity can become quite hot and would be undesirable from this point of view. Standard greenhouse structure have a large proportion of their cost involved in the structural members, so it may be expected that the evaporation tubes of the preferred embodiments would offer a considerably cheaper alternative from a capital cost perspective.

The evaporation chambers described in the preferred embodiments can be operated so as to control the liquid evaporation to any desired rate depending on the selection of fan operating speed, and air throughput, as well as the extent to which the sun is available to heat the chamber and enhance the evaporation rate. One of the major advantages of this type of equipment is that the material being evaporated is completely sealed from the surrounding environment, so that very toxic substances present in liquids can be isolated without fear of contaminating local groundwater. The tubular structures of the preferred embodiments have a lower footprint (ie. take up less ground area) than would be the case for an open pan evaporation system, and can be positioned on the contours of a hillside in an undulating geographic region.

The tubes 12, 120 have the additional advantage of being sealed to ingress of diluents such as rainwater or groundwater run off. In fact, if solid and liquid mixtures are subject to evaporation in the preferred tubular evaporation chambers 12, 120, it is possible to dry out these mixtures completely in a batchwise manner so that the dried solids can be collected and used for other purposes or properly disposed of. In order to collect the solid materials, in some embodiments the evaporation tube can be deflated and then lifted or moved into a position where the

solids can be dry discharged and collected. This collection and removal operation can also be conducted after longer term continuous evaporation processing is concluded, usually when the inner base of the evaporation tube becomes sufficiently filled with deposited solid matter. The convenience of such removal of course depends on the size and shape of the evaporation tube used.

The evaporation tubes 12, 120 of the preferred embodiments can be applied to the evaporative drying of many water-based effluent streams, such as mine tailings dam runoff, particular where that runoff cannot be allowed access to the groundwater (eg uranium mine water, gold mine cyanide-containing waste waste). In applications from industry to farms and feedlots, it is also important that water that is heavily contaminated with pesticides, or with various organic contaminants, be collected and evaporated to concentrate the undesirable solid material for proper disposal or further treatment. In one example, a liquid containing organic contaminants that are the by products of a wool scouring operation can be collected and evaporated to leave a concentrated organic solid material which is potentially rich in potassium for further use as a fertiliser. The organic contaminants, which otherwise cannot be allowed to enter the local ground water table (which provides a source of drinking water for an urban region) can thus be usefully re-used elsewhere as a vendible product.

In any of the preferred embodiments mentioned, it would also be possible to locate one or more pipes in the lower interior portion of the evaporation tubes. These pipes can contain any fluid which requires heating, so that some of the solar energy collected by the evaporation tubes can be used for heating the fluid. The pipes can typically be made

of black polypropylene or other materials, and the heated fluid can be used to transfer heat to other processes in a domestic or industrial application of the apparatus of the invention.

The apparatus of the invention can also be applied to the desalination of groundwater in arid areas provided that the vaporised water can be condensed in some sort of external condensation apparatus. In a further preferred form of the invention as shown in Figure 9, a tubular evaporation apparatus 210 is arranged for floating on a body of liquid 250, for example the ocean or a lake. In such an embodiment, salty or brackish water is introduced into the inflatable evaporation chamber 212 via inlet hole 224. The chamber 212 is fitted with fluid control means in the form of an inlet gas fan 214 and a gas outlet hole 216. Once again the capacity of the inlet gas fan 214 and the size of the outlet hole 216 are matched so that the degree of inflation of the chamber 212 can be maintained, and also so the apparatus 210 can float on the body of liquid 250 (ie. the combined weight of apparatus and liquid being evaporated is made buoyant by the volume of entrapped gas in the chamber 212.) The evaporation chamber 212 is generally made of the same materials as described earlier for the evaporation tubes 12, 120. In all respects the evaporation chamber 212 operates similarly to the evaporation tubes 12, 120, and thus a repeat description of the use of the chamber 212 is not given here. Where indicated in Figure 9, like parts as shown in the embodiment of Figures 1 to 5 are given corresponding numbers with an additional "2" prefix.

In the embodiment of Figure 9, the outlet hole 216 is joined to a tubular section 252 protruding from the chamber 212 and extending therebelow into the body of

liquid 250. In this tubular section 252 the evaporated water vapour (heated by the action of the sun on the chamber 212 and removed by the action of the fan 214) can be condensed because the ocean water is likely to be cold, particularly at depths lower than the floating chamber 212 (at depths where the sun does not heat the water 250). The condensed water vapour can then be extracted from the lowermost portion 254 of the tube 252 by a pump 256 and sent elsewhere for use.

The materials of construction of the evaporation chamber portion of the apparatus can comprise any suitable materials which can be shaped, formed and fitted in the manner so described, such as flexible plastics which can be injection moulded to give a structurally sound apparatus that can withstand extremes of weather and temperature.

It is to be understood that, if any prior art information is referred to herein, such reference does not constitute an admission that the information forms a part of the common general knowledge in the art, in Australia or any other country.

Whilst the invention has been described with reference to a number of preferred embodiments it should be appreciated that the invention can be embodied in many other forms.

CLAIMS

1. Evaporation apparatus including:
   - an evaporation chamber that is inflatable; and
   - fluid flow control means for controlling the respective introduction and release of gas to and from the chamber to control the inflation of the chamber,

wherein in use the inflated chamber is adapted for containing a volume of liquid to be evaporated and carried out of the chamber by the gas in a vapour.

2. Apparatus as claimed in claim 1 wherein the fluid flow control means is used to control the gas pressure and the flow rate of gas within the chamber.

3. Apparatus as claimed in claim 1 or claim 2 wherein the fluid flow control means includes a fan for introducing gas into the evaporation chamber, the fan sealably positionable at a hole made in the wall of the chamber.

4. Apparatus as claimed in claim 3 wherein the fan is a variable speed fan.

5. Apparatus as claimed in any one of the preceding claims wherein the fluid flow control means also includes an outlet pressure release valve via which gas is released from the chamber, the valve sealably positionable at a hole formed in the wall of the chamber.

6. Apparatus as claimed in any one of the preceding claims wherein the evaporation chamber is an enclosure made of a flexible wall material.

7. Apparatus as claimed in claim 6 wherein the enclosure is made of a plastic material.

8. Apparatus as claimed in claim 6 or claim 7 wherein the enclosure is elongate and tubular in shape.

9. Apparatus as claimed in any one of the preceding claims wherein the liquid to be evaporated can be introduced into the enclosure in a batchwise or a continuous manner via a liquid introduction port located in the exterior of the enclosure.

10. Apparatus as claimed in any one of the preceding claims wherein the vapour released from the chamber can be condensed by a condenser means located external of the evaporation apparatus.

11. Apparatus as claimed in any one of the preceding claims wherein the evaporation apparatus is adapted to be floated on a body of liquid.

12. Evaporation apparatus substantially as herein described with reference to the accompanying drawings.

Dated this 26th day of August 2002
GOULBURN WOOL SCOUR PTY LTD
by its Patent Attorneys
GRIFFITH HACK

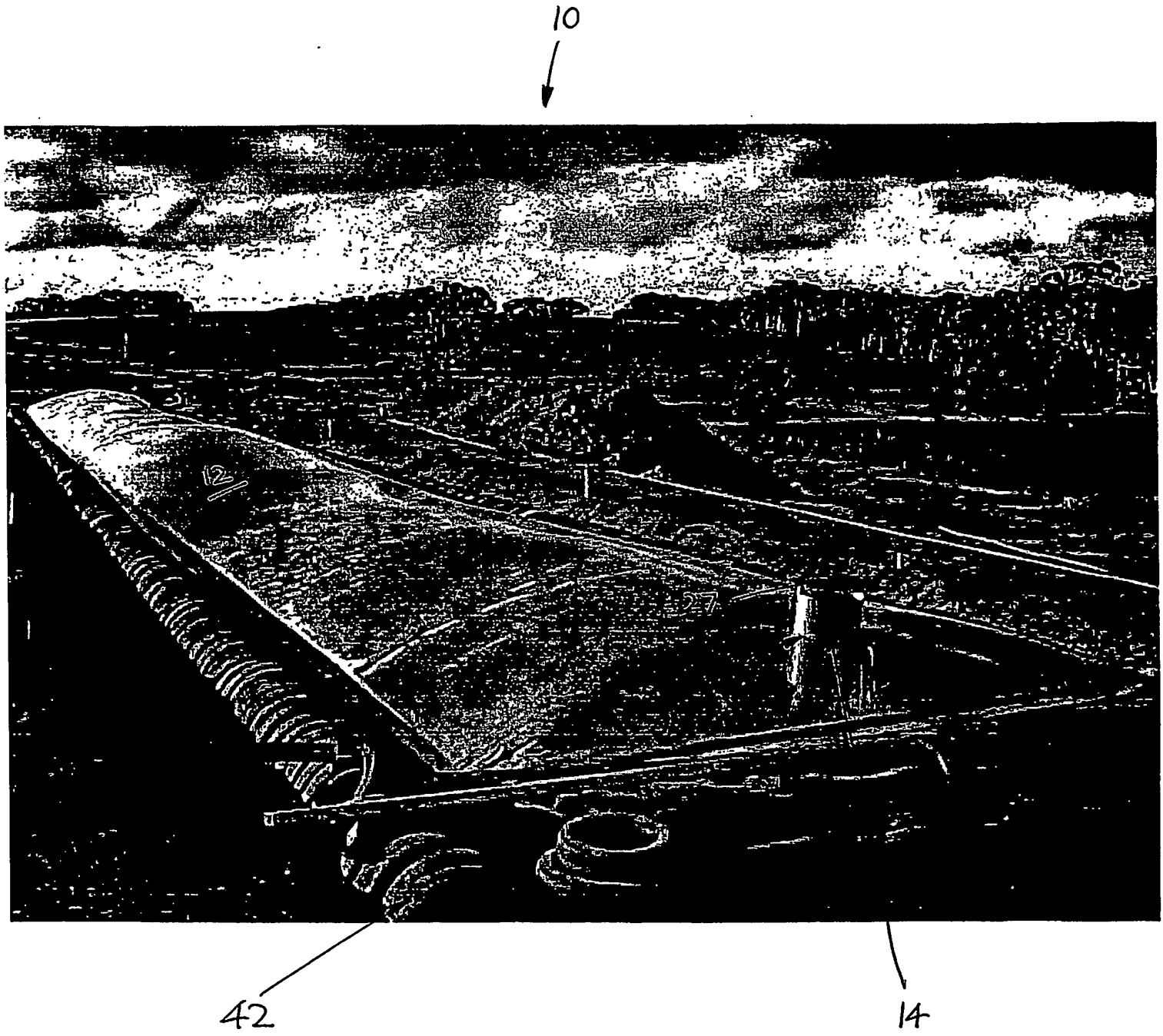

FIG. 1

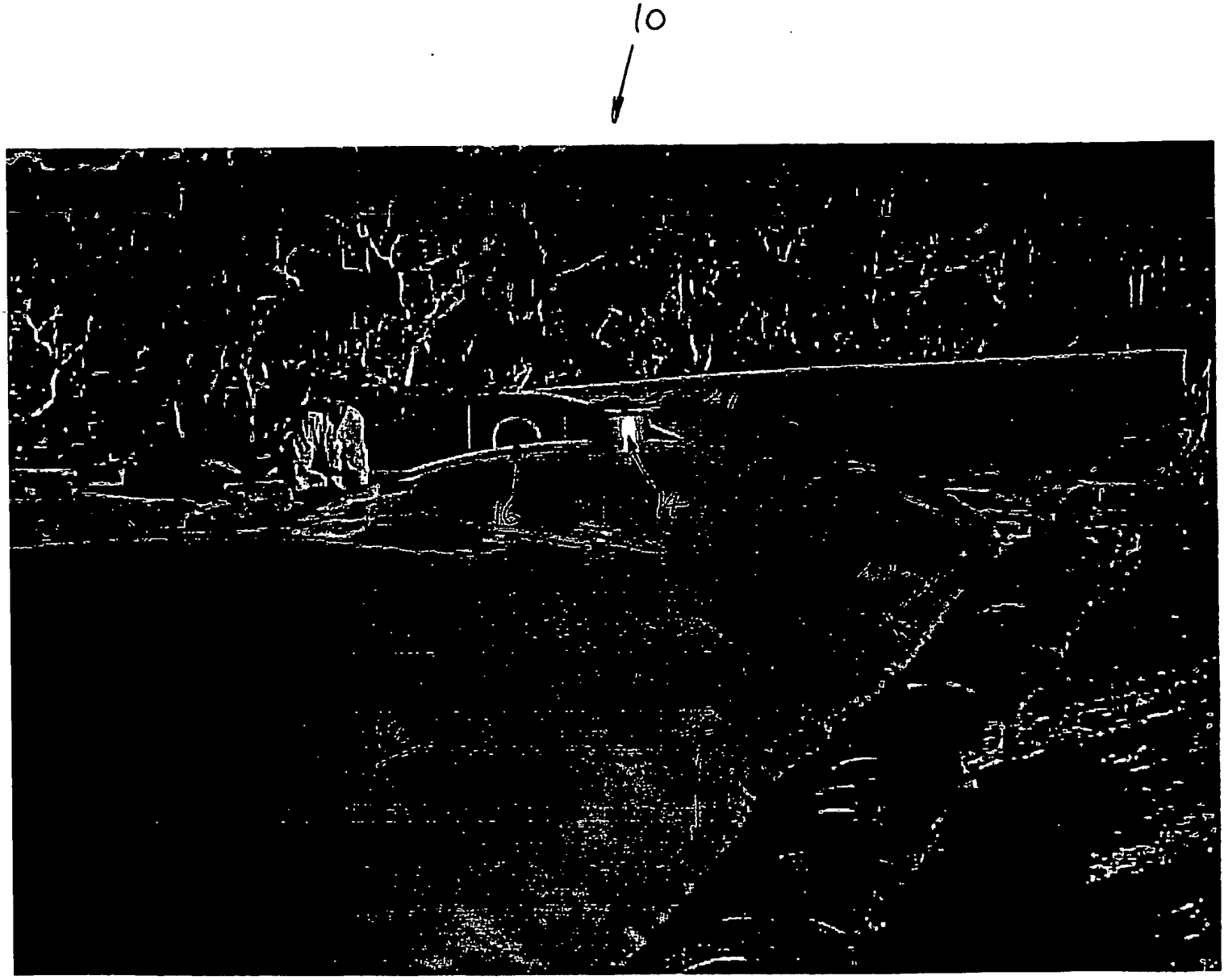

FIG. 2

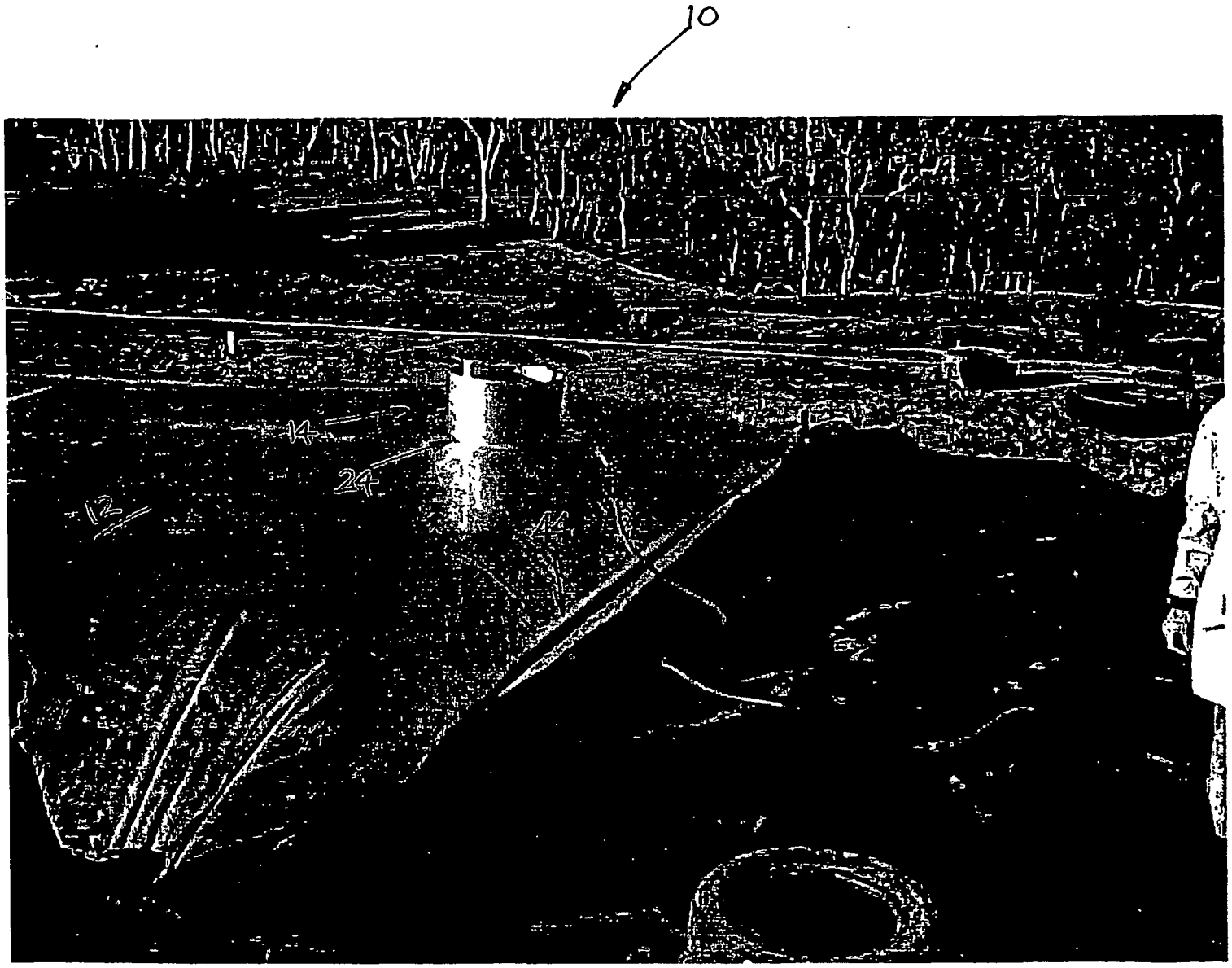

FIG. 3

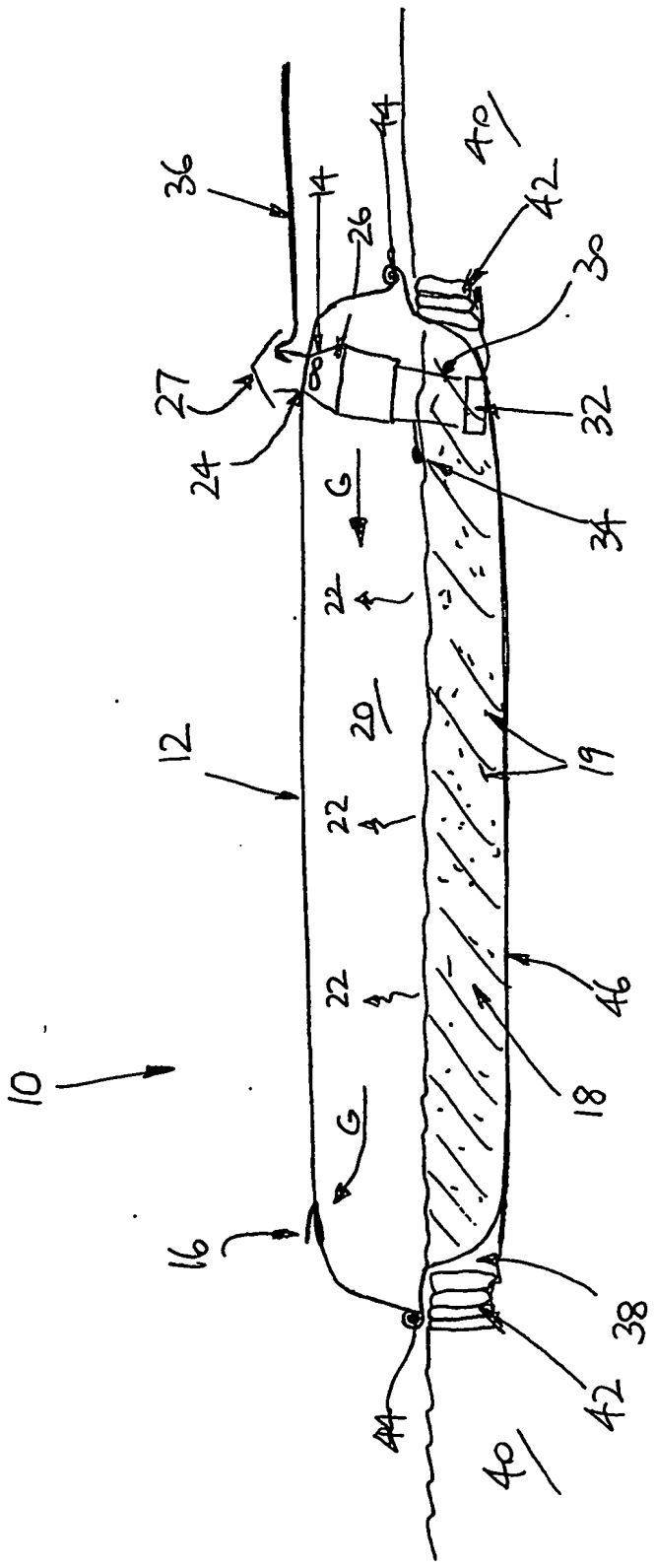
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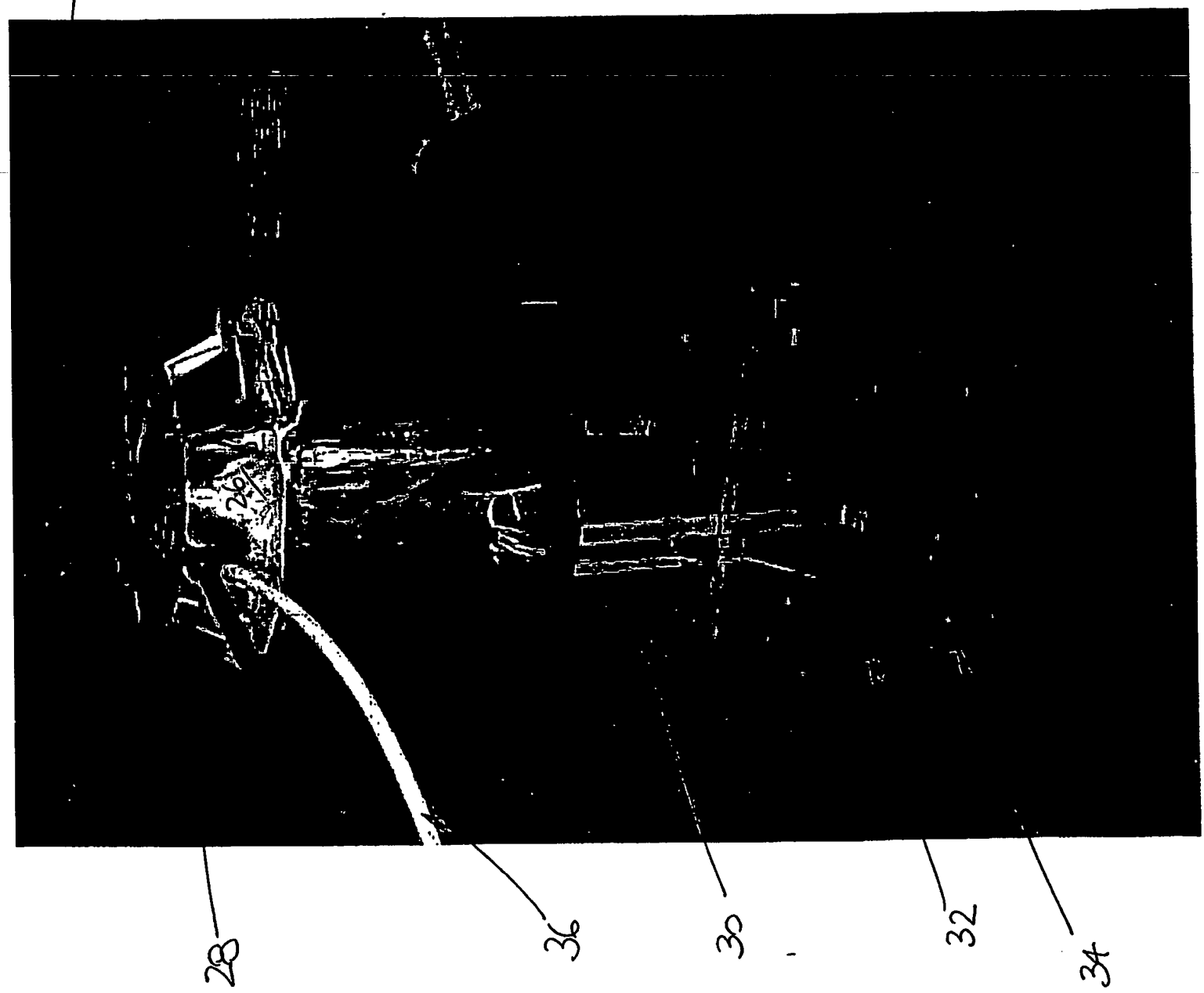
FIG. 4

FIG. 5



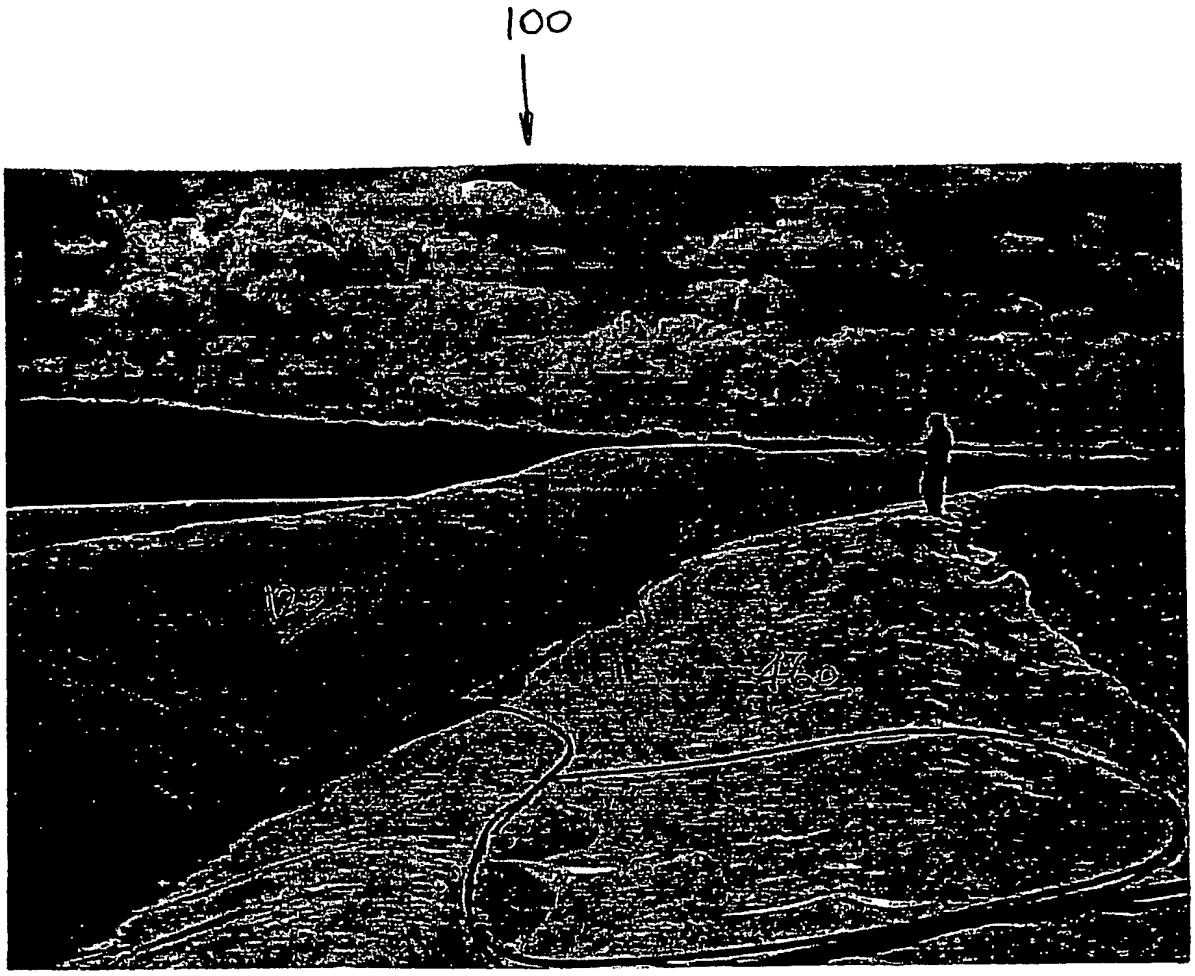


FIG. 6

FIG. 7

FIG. 8

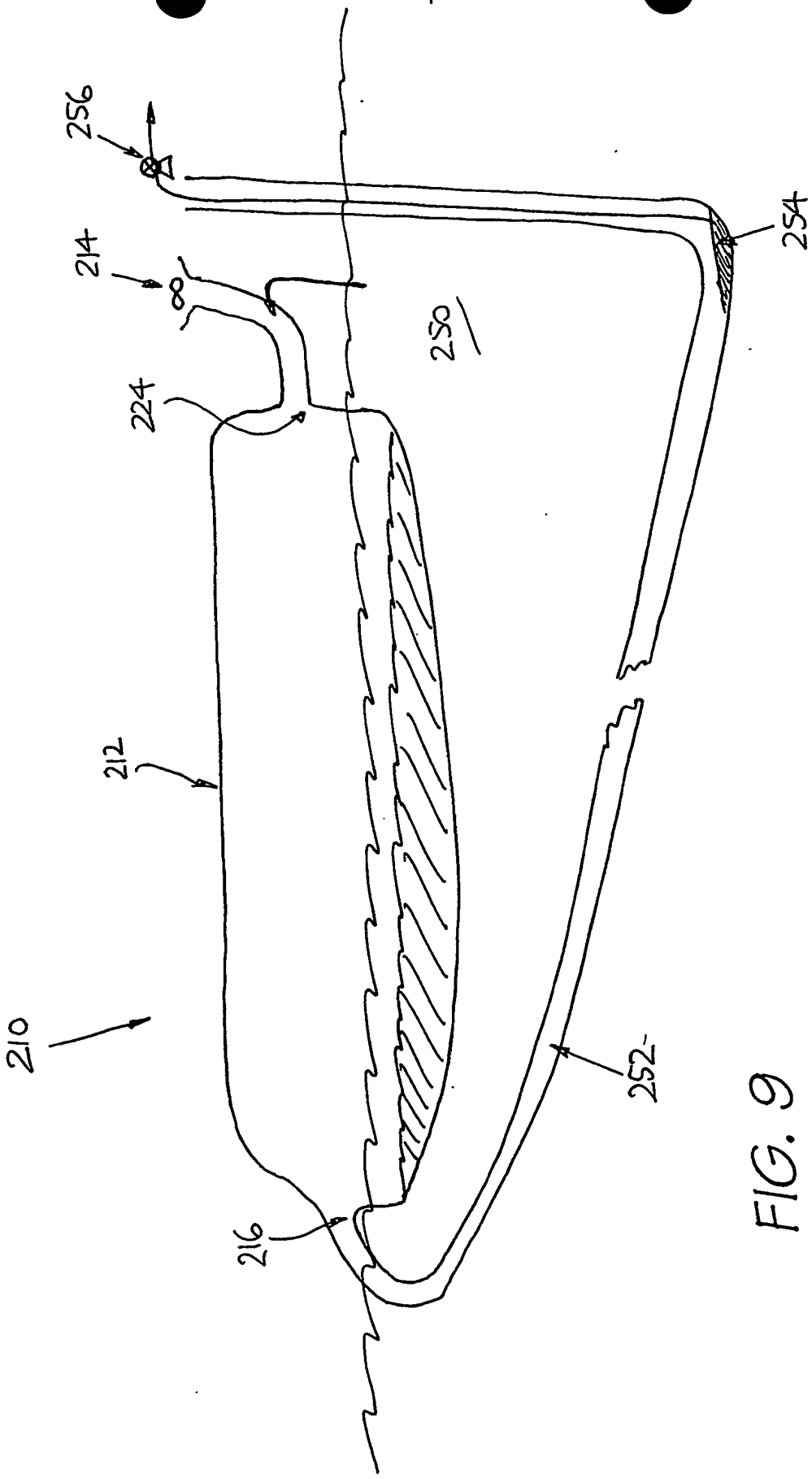


FIG. 9